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Simultaneous Telephony and Power Transmission Over the Same Wires

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SIMULTANEOUS TELEPHONY

AND

POWER TRANSMISSION OVER THE SAME WIRES

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THESIS

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THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

THOMAS HAMER AMRINE and CHARLES CLEMENT CARR

ENTITLED SIMULTANEOUS TELEPHONY AND POWER TRANSMISSION OVER THE SAME WIRE

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science in Electrical Engineering

Morgan Brooks

HEAD OF DEPARTMENT OF Electrical Engineering

SIMULTANEOUS TELEPHONY AND POWER TRANSMISSION OVER THE SAME WIRES.

OBJECT-

The object of this thesis is to devise a method of simultaneous telephony and power transmission over the same wires.

DISCUSSION -

The advantages of being able to use the wires of a power transmission line for telephony between the substation and the power house or between two substations is obvious. Rendering, as it would, the use of a separate telephone wire unnecessary on the pole line the poles could be made shorter, thus decreasing the cost of construction.However, where there is any danger from the high tension current to the operator using the telephone, the safety of the device is of much greater importance than cheapness of construction. In telephoning over a line which is on the same poles as the transmission wires there is danger both from direct connection with the high tension current and from a static shock from the charge held between the high tension wires and the telephone wires. With a telephone wire running parallel to and only a few feet from the high tension wire, a slight accident may make a cross between the two circuits. Moreover, this chance of accidental contact between the circuits, due for instance to a broken wire, extends over the entire length of line, which would probably be several miles. It is at the time of an accident of this kind that a telephone is most needed to make reports regarding the accident and to give orders for its repair, but it is then that the use

of the telephone, if not impossible, is most dangerous. By using the high tension wires for simultaneous telephony and power transmission and having only an inductive connection between them and the telephone apparatus the chance of accidental contact of the two circuits is localized in a portion of the circuit that may be thoroughly insulated and protected. For this reason the danger from direct contact with the high tension current is much decreased. Since no separate telephone wire is used, of course, the danger from a static shock is entirely eliminated.

The principle upon which the entire set of experiments is performed is based is that the power current has a frequency generally of either 25 or 60 cycles per second while the telephone current has a frequency of from about 300 to 500 cycles per second. A method of separating the rather low frequency of the power current from the high frequency of the telephone current is then the first thing necessary for a satisfactory solution of the problem.

Since a large inductance will act almost as an open circuit for very high frequencies, but will allow a low frequency to pass through with much greater ease and since a very small condenser has the reverse effect, that is, offers a much less impedance to a high frequency than to a low one, it was thought that the proper adjustment of capacity and inductance would separate the two currents of different frequencies.

EXPERIMENTS-

The first experiments were conducted for the purpose of finding how small a condenser could be used to talk through satisfactorily and at the same time cut down the low frequency current sufficiently so as not to interfere with conversation. Apparatus was con-

nected as shown in Fig. 1.

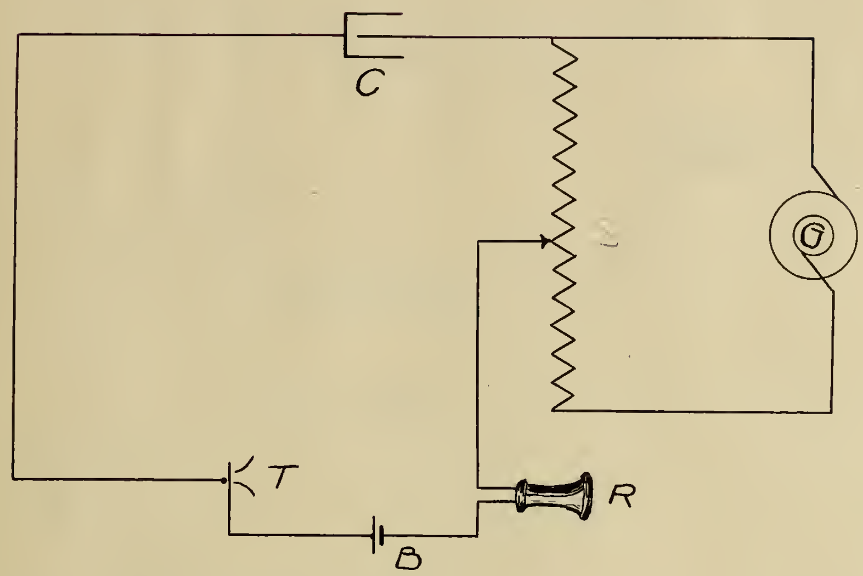

Fig. 1.

S is a rheostat, C a small condenser consisting of two sheets of tin 14 inches square, separated by a piece of ordinary bond paper, R the reciever, T the transmitter and G is an alternator giving 110 volts at 60 frequency.It was found that the condenser had a capacity great enough to make talking through it possible. When the voltage was cut down to from 50 to 70 volts by means of the rheostat there was scarcely any sound in the reciever from the alternating current, but when the pressure was increased to 110 volts the sound was more audible, but did not seriously hinder conversation.

The experiment to ascertain approximately the size of inductance necessary to satisfactorily separate the two frequencies was made with connections shown in Fig. 2. L was the inductance, the necessary size of which was to be determined, C a small condenser and I the ordinary telephone induction coil.

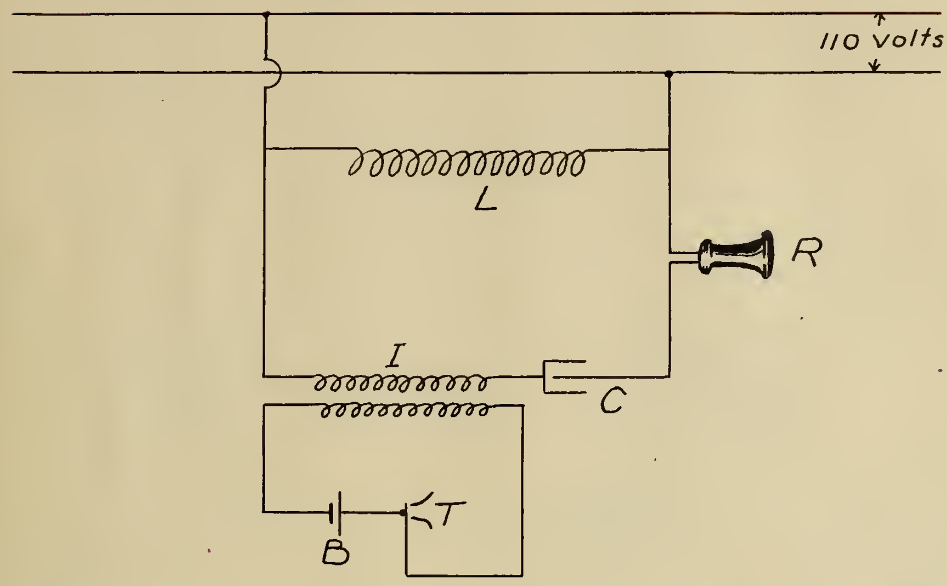

Fig. 2.

It was found that L must be a very large inductance, for instance, that of the primaries of three 1 K.W. transformers and a condenser at C consisting of only two sheets of tinfoil 4 inches square separated by ordinary bond paper were necessary to secure approximate silence of the alternating current.

The connections given above are not attempts at telephoning over the transmission line, but simply to get an idea of the size of inductance and capacity necessary for the proper balancing of the low frequency, high tension current from the telephone reciever. The first scheme used in the attempt to telephone over the transmission line was that shown in Fig. 3. The transmission line was a 110 volt, 60 cycle line feeding incandescent lamps for a load. S is a series transformer having a ratio of 8 to 1 , L is a large inductance consisting of the primaries of three 1 K.W. transformers. The double throw, double pole switch made it possible to throw the telephones together on a direct circuit K so that the operators

could be in communication whether it was possible to talk over the transmission line or not. C was the small condenser described before and I is the induction coil.

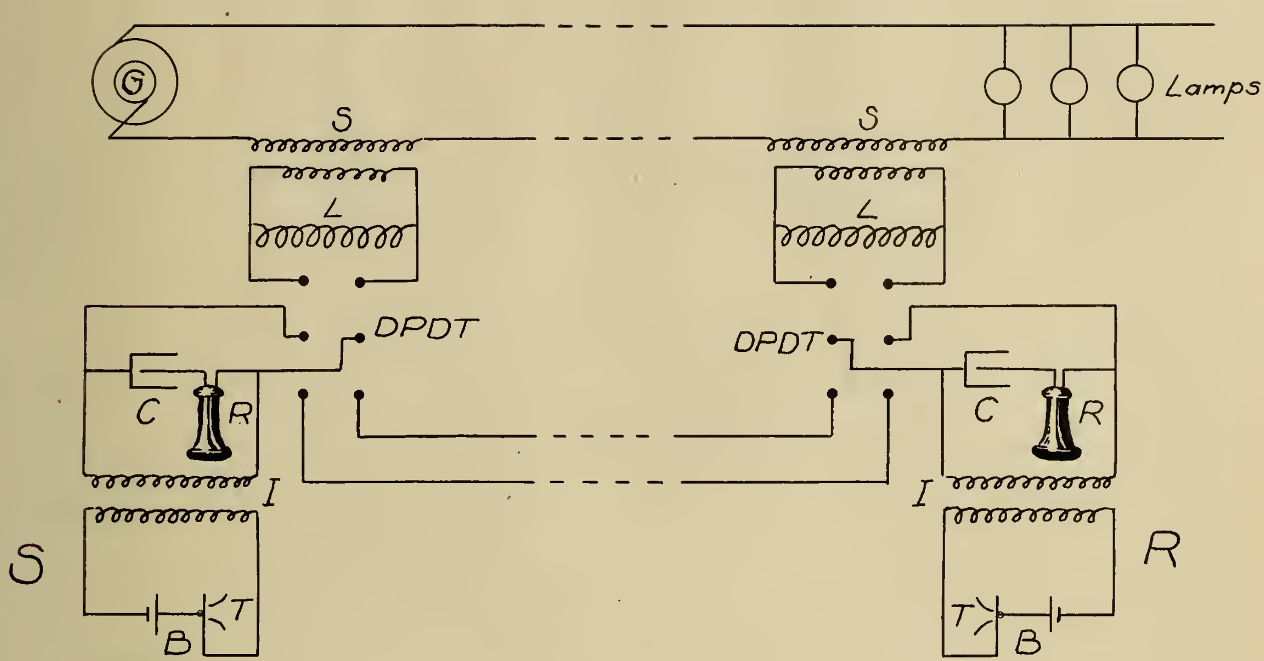

Fig. 3.

The theory of this scheme is as follows. The high frequency telephone current produced at the transmitter passes through the induction coil and the series transformer out on the line to the other series transformer and into the local telephone ciccuit at the recieving station R. The high inductance L provides no easy path for this high frequency, so it passes on to the reciever circuit containing the condenser. This condenser permits the current to pass through it and the reciever, thus reproducing the sound made at S. The low frequency power current which also comes through the series transformer into the local circuit is short-circuited by the inductance L and the secondary of the induction coil I instead of passing through the condenser and reciever which offer a high

impedance to the low frequencies.

With this scheme talking was found to be possible over the total variation of pressure used, that is, from 110 volts to 440 volts with equal ease, but the inductance used was large and costly and the balance between the capacity and inductance was lost as soon as the load was changed. This, of course, renders this scheme unpracticable, because in practice the load current varies considerably from moment to moment.

An attempt was next made to introduce a condenser in series with L of such a capacity that for 60 frequency there would be a condition of resonance established in that part of the circuit.The connections are shown in Fig. 4.

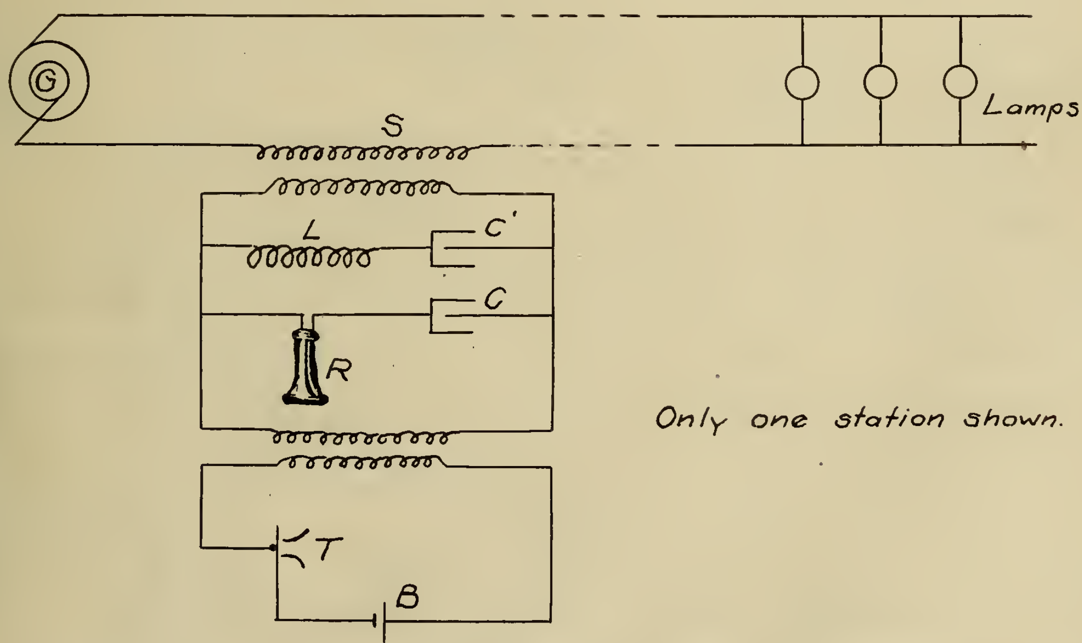

Fig. 4.

L and C' were adjusted to resonance as nearly as possible. C was a condenser smaller than any used before, composed of two sheete of tinfoil 1 1/4 inches square with paraffine paper insulation. It was found that by the proper adjustment of L and C the

system could be balanced almost perfectly for any one load so that no souns of the alternating current was noticeable, but when the load was changed the balance was lost. The trouble lay in the fact that L must be large in order to keep the voice currents from being shunted around the reciever and consequently the inductance coil L must have an iron core so as to reduce its size to practicable dimensions. With iron in the core, however, the inductance changes rapidly with the current since the iron is being worked low on the magnetization curve.Hence L and C' do not remain in resonance and the scheme is really the same as that of Fig. 3 as soon as the load is changed any amount. It looks reasonable that with an inductance at L without iron the system would remain adjusted for any load.The function of LC' is, of course, to provide an approximate short circuit for the low frequency current since they are in resonance. It helps prevent this current from passing through the reciever R and is aided in this by the very small condenser C. LC' is not in resonance for a current of voice frequency and since C' has a very small reactance for this frequency it is practically the same as a simple inductance which will prevent the voice currents from shunting around the reciever. L hence must be larger in inductance than the secondary S' of the series transformer, in fact, what is wanted is a difference of inductance between L and S' in favor of L. This might be done by decreasing the inductance of L and suggested the abolishment of the series transformer and the trial of a scheme using static induction between the line and the local telephone circuit.

In the scheme using static induction a grounded telephone circuit was used. The connections are shown in Fig. 5. C was the small condenser used in the last scheme tried and C' was a larger

condenser consisting of four sheets of tinfoil about two inches square. L was an inductance consisting of the low current coil of a Westinghouse 8 to 1 switch board current transformer. Care was taken to have both grounded telephone circuits on the same side of the line.

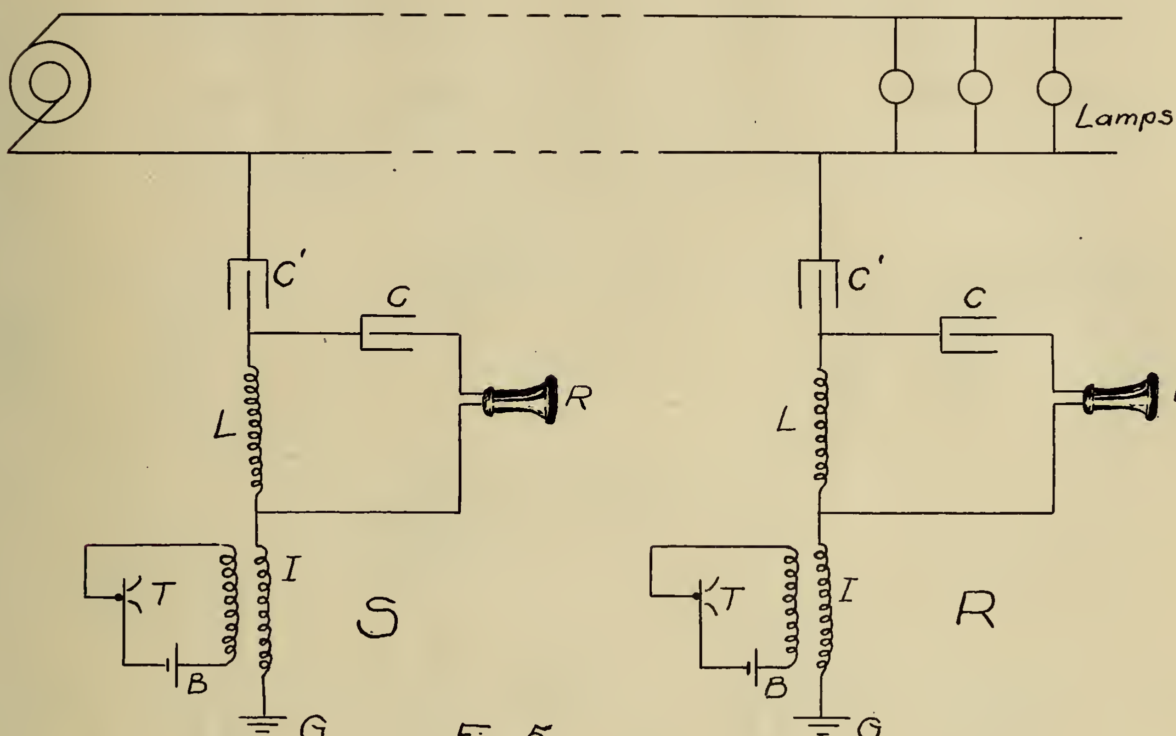

Fig. 5.

For 110 volts on the line this scheme worked admirably, the talking being very distinct and the alternating current being scarcely noticeable. The load was changed from 2 to 22 amperes with no difference in the talking or in the noise of the alternating current. 440 volts were then tried on the line with 5 lamps in series for a load. While the sound of the high pressure current was not a serious hindrance to talking it was at once concluded that this system would not be satisfactory for high voltages, because if C were made small enough to cut down the current in the telephone circuit so that the alternating current would not be heard, then it would be so small

that it would be impossible to talk through it. Hence this scheme was abandoned.

Two of the schemes described had each been, so to speak, half way a success. The one shown in Fig.3 worked well for any variation of pressure, but it was possible to use it only if the current on the line remained constant. The one shown in Fig.5 was found to be impossible on high voltages, but it would work equally well with any current which was put on the line. An attempt to combine the good features of both schemes resulted in using the connections shown in Fig.6.

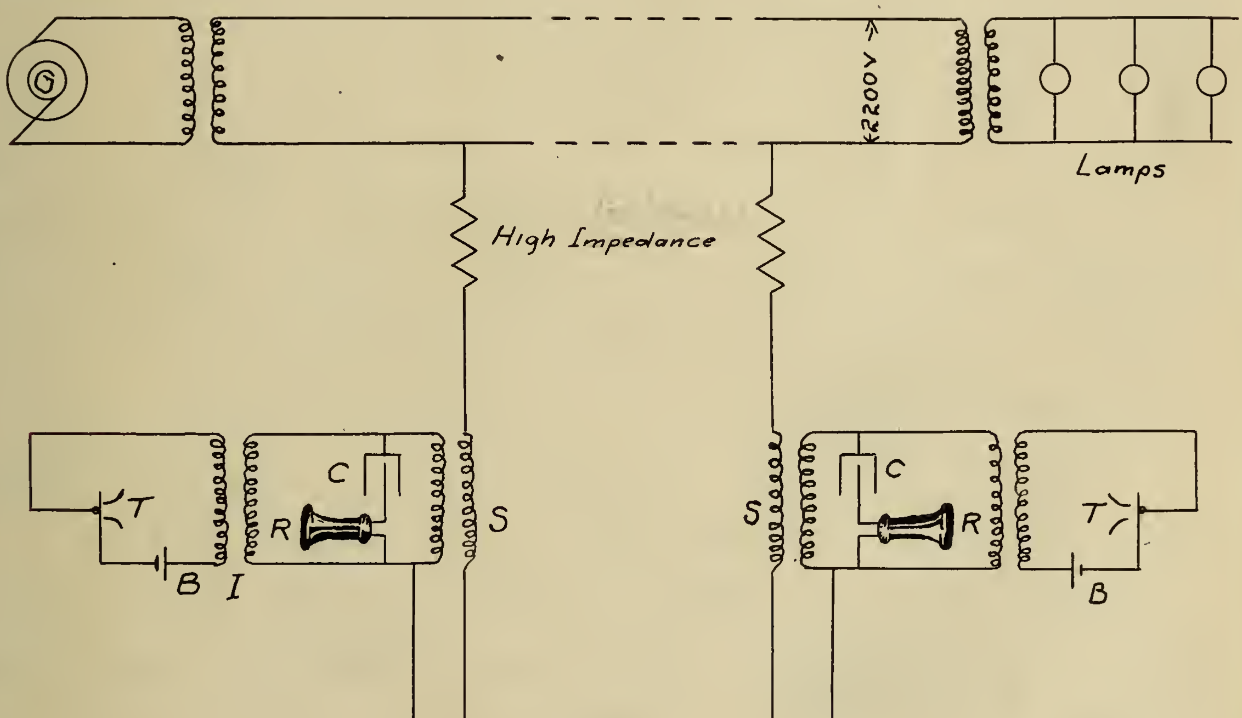

Fig.6.

S was an ordinary telephone induction coil used as a series transformer. Care was taken as in the connections in Fig.5 to have both local circuits on the same side of the line. The receiver circuits should be grounded as a protection to the person using the telephone in case of failure of the insulation between the two

coils of S and a ground on the other side of the line. As a protection to the transmission line in case of a ground on the other side a high resistance should be introduced in the ground circuit at each end and a high ~~resistance~~ tension circuit breaker introduced. This would give perfect protection to the operator and to the transmission line in case of accidents. A pressure of 110 volts was used at first with this system with a load of two 110 volt lamps. The telephone talked well and the alternating current was almost absolutely quiet. The load was increased to 32 lamps, but no difference could be noticed in the sound of the alternating current; it remained very quiet. Four lamps were then put in series and 440 volts were impressed on the line. The sound of the alternating current was no louder than with the 110 volts. The load was then increased to four times the former amount, but the talking continued to be very satisfactory. An inductance coil containing iron and of a fairly high resistance was introduced in the line to approximate the conditions in a longer line, but niether the talking nor the sound of the alternating current was changed at all as far as the ear could determine.

All the experiments up to this time had been on the lines in the laboratory, but to try this last scheme on a higher voltage than had yet been tried an experimental line several hundred feet long was constructed out of doors with a transformer for stepping the pressure up to 2200 volts. The apparatus was put on this line and with loads on the secondary of the step-down transformer varying from 1 to 17 amperes were used. The telephone seemed to talk as well as it did over the lower voltage and the sound of the alternating current sounded no louder than for 110 volts. In fact the scheme worked in a very satisfactory manner and with some refine-

ment in apparatus and adjustments it seems probable that it could be made a commercial success.